Eighth Series, No. 5 November 4, 1916

Teachers College Bulletin

The Determination of Cotton and Linen

By Physical, Chemical and Microscopic Methods

BY

ALOIS HERZOG, PH.D.

Director of Department of Flax Culture, Prussian Higher Technical School for the Textile Industry, Sorau, N. L.

TRANSLATED FROM THE SECOND EDITION BY

ELLEN BEERS McGOWAN

Instructor in Household Arts, Teachers College

Technical Education Bulletin, No. 7

PRICE, 25 CENTS

Published by

Teachers College, Columbia University

525 West 120th Street

New York City

Teachers College Bulletin

Published fortnightly from September to May inclusive. Entered as second class matter January 15, 1910, at the Post Office at New York, New York, under the Act of August 24, 1912.

M.9.21.

Eighth Series, No. 5 November 4, 1916

Teachers College Bulletin

The Determination of Cotton and Linen

By Physical, Chemical and Microscopic Methods

BY

ALOIS HERZOG, PH.D.

Director of Department of Flax Culture, Prussian Higher Technical School for the Textile Industry, Sorau, N. L.

TRANSLATED FROM THE SECOND EDITION BY

ELLEN BEERS McGOWAN

Instructor in Household Arts, Teachers College

Technical Education Bulletin, No. 7

PRICE, 25 CENTS

Published by

Teachers College, Columbia University

525 West 120th Street

New York City

INTRODUCTION

THIS pamphlet, a translation of Professor Herzog's "Die Unterscheidung von Baumwolle und Leinen,"[1] is offered as a useful handbook for persons concerned with textile manufacture, instruction, and especially textile purchase and use. Textiles have become a subject of importance to the purchaser since household manufacture has passed by with its intimate acquaintance on the part of maker and user with the characteristics and values of different fibres and fabrics, and in its stead has come the situation of purchaser on one side the counter, and sales-person on the other, both equally ignorant of textile values, often of textile identity. But sales-people on their part are trying to increase their knowledge: the instruction in salesmanship which has been organized in many places gives textiles its proper place in the curriculum. Schools of household arts and college departments of home economics have for several years recognized the necessity of textile study to educate the consumer. But there has been a dearth of scientific material available. The schools of textile technology all give instruction in textile chemistry and other applied science necessary to equip the successful manufacturer, or the producer, of textile goods. If we may believe the cynics, such schools indeed train the producer in shrewder methods and darker matters than the consumer may ever hope to unravel or bring to light. Fairly judged, however, modern textile manufacture where it has been criticized has simply devised ways of producing expensive effects with cheap materials, as mercerizing cotton to make it look like silk, and weighting actual silk with tin salts to give what seems heavy silk at costs far below pure silk. Such attempts go wrong when either the customer buys ignorantly and laments afterward, or when the manufacturer actually overshoots the mark in his endeavor to produce cheap but attractive goods and produces defective ones with a low wearing efficiency. We none of us desire to go back to unbleached muslin and butternut gray, but we have a right to demand a dollar's worth of wear as well a dollar's worth of effect from our clothes.

1 Verlag fur Textile-Industrie, Berlin, S. W. 48.

The remedy is more science—more for the manufacturer, more for the consumer. Good bridges are built for stress and strain as well as beauty. We ask as much of our textile fabrics. The United States Army examines for tensile strength, fastness of dye, and trueness of fibre, every roll of cloth, consignment of men's hose, etc., that clothes the soldier. Progress for us all will come, it seems likely, through an honest system of labelling, so that, for example, cotton blankets will not by a "trade custom" be labelled "all wool," as was done in one of New York's best stores a year or so ago; perhaps "standards" or definite grades can be established in certain lines; possibly the suggested Federal legislation for pure textiles, comparable to pure food legislation, will bear fruit. But at any rate progress is certain—we cannot permit hospitals and large institutions to administer the budget item of hundreds, perhaps thousands of dollars for linens and textiles upon a basis of rule-of-thumb and ignorance, nor will the individual forever bear being hood-winked with textile mixtures when he wishes and is willing to pay for pure goods, whether in wool, in linen, or in silk. Health and the pocketbook—a strong combination—are both concerned. The same degree of publicity that has been secured for food manufacture is asked—and this knowledge will save the situation for producer and consumer alike.

The translation of Professor Herzog's little brochure has been faithfully made by Ellen Beers McGowan, instructor in household arts, Teachers College. The methods which it outlines have been used in the course in textiles in the School of Practical Arts. It is hoped that this translation may be useful in other institutions, and to individuals concerned with textiles, whether in manufacture, sale, or purchase.

Cordial acknowledgment is to be made to the author, Professor Herzog, Director of the Department of Flax-Culture in the Prussian Higher Textile School of Sorau, for permission to make the translation, and to his publishers, der Verlag für Textile Industrie of Berlin, for making available the illustrations.

BENJAMIN R. ANDREWS

ASSISTANT PROFESSOR OF HOUSEHOLD ARTS,
TEACHERS COLLEGE, COLUMBIA UNIVERSITY

August, 1911

AUTHOR'S PREFACE

During my practical work in the linen industry, I had ample opportunity to observe what great commercial and technical importance attaches to the distinction between flax and cotton fibres. Unfortunately, I was obliged equally often to notice that the knowledge of the distinguishing marks has not penetrated to a very wide circle, and indeed that the judgment of many engaged in the textile industry is unreliable as soon as it comes to a question of tests of material of unknown origin or of cotton goods which on account of dressing look like linen.

In this publication, now in its second and essentially enlarged edition, I have considered especially the methods of testing which it is possible for everybody to carry out quickly and without complicated apparatus. Of course I was obliged to mention also the most important method of identifying both fibres—the microscopic test, which gives unquestioned scientific results. The somewhat more detailed handling of this subject here as compared with the first edition, will be, I hope, to many not unwelcome.

The special value of this entirely practical pamphlet was the introduction of original photographs, which would enable one entirely unskilled, by carefully comparing them with specimens prepared for the microscope, to gain the desired result. The larger number of illustrations in this second edition should therefore increase the practical usefulness of the pamphlet.

A. HERZOG.

Sorau, N. L., March, 1908.

The Determination of Cotton and Linen

I. Simple Physical and Chemical Differences Between Cotton and Linen

In view of the great difference in price between bleached linen and cotton materials, it is not surprising that for some time simple methods of recognition of the fibres named have come into use, based partly on physical and partly on chemical differences. Although many of these "tests" allow great latitude for individual judgment, so that they are not always scientifically conclusive, it is undeniable that some, for instance the oil test, give good results in skilled hands. Although in general I agree with Wiesner that for technical practice scientific methods of examination should alone be authoritative, I hold that in the present case it is going too far to reject, as empirical, certain physical and chemical identification tests for linen and cotton, since by their help good results may be obtained with a minimum of time and apparatus. Upon like grounds the technical chemist would be obliged to discard many very useful tests, as the blowpipe test, color reactions with oils, breaking test for metals, etc., although these are entirely satisfactory as preliminary tests in the laboratory and in the management of manufacturing establishments.

As preliminary working tests the following methods of distinguishing between cotton and linen should be considered. Many of them (as the oil test) are of great importance in microscope work, as for example when it is a question of the presence of cotton threads in a linen weave. In this case it would cause loss of time if one should use the microscope to distinguish all the threads. As experience shows, it is amply sufficient to test with the microscope only those threads which appeared doubtful in the preliminary examination.

A. Physical Tests

1. Tearing Test.

In general linen weaves are more difficult to tear than cotton. The torn ends of linen appear unequal in length, parallel fibred, and glossy. Cotton shows curling, lustreless threads of almost equal length. (See Figs. 1 and 2.)

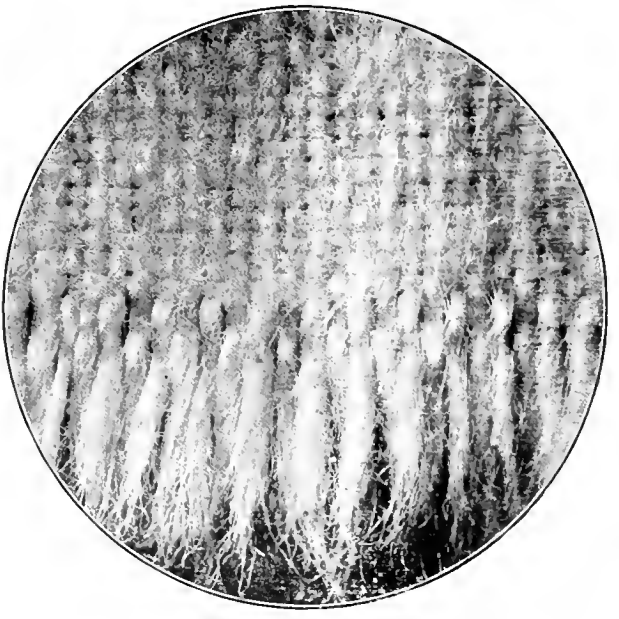


Fig. 1. Torn end of cotton material. Mag. 8x.

Fig. 2. Torn end of linen material. Mag. 8x.

With practice it is possible to distinguish between the sounds resulting from tearing the material:—Linen, *shrill;* cotton, *dull* or *muffled*. If yarn is broken quickly, cotton fibres will curl, while linen fibres remain stretched.

2. Untwisting Test.

Cotton threads are made up of a number of fibres so interwo[illegible]ting they show different directions in each

Fig. 3. Untwisted linen yarn—three threads at right; and cotton yarn—three threads at left. Mag. 8x.

turn of the fibre, while linen threads similarly handled show a more or less parallel arrangement of the glossy individual fibres. (See Fig. 3.)

3. Light Test.

On examination of material held against the light (or in refracted light), flax fibres appear strikingly streaked or uneven, while cotton fibres are marked by great uniformity. (See Fig. 4.) The streaking in the former case is always present in the flax yarns (linen and tow) and is technically attributable to unavoidable inequalities in the thickness of the threads.

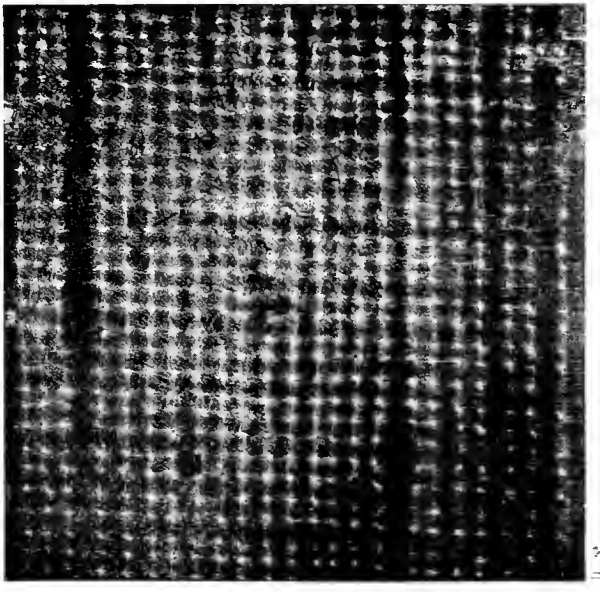


Fig. 4. Half-linen goods examined against the light. The linen threads are marked by knotty places. Mag. 4x.

4. Singeing Test. (Stockhardt).

Burned ends of linen threads, after the flame is extinguished, appear scorched in an even, compact manner, while cotton threads similarly treated spread apart more or less like a paint brush. (Fig. 5.)

Fig. 5. Singed cotton threads at left and linen threads at right. Mag. 10x.

5. Oil Test. (Frankenstein).

This test, in a somewhat modified manner, is carried out as follows: The piece of goods, freed from dressing by boiling out in water or warm soda solution, is laid on a glass plate, saturated with fatty oil, and, avoiding air bubbles, covered with a smaller glass plate. After the removal of the surplus oil from the edges of the cover glass, the sample is examined, first against the light, then with the light falling on the object. The linen fibre because of its thick cell wall, which approaches the refractive index of the oil, assumes a transparent appearance, like a grease spot on paper; i. e., it appears clear against the light, and dark when light falls upon it. The opposite effect is noticed in cotton. Hence the latter appears bright with the light falling upon it, and dark against the light, not only because the air in the relatively thin-walled cell of the lumen is not replaced by the oil, but also because the air bubbles between the separate intertwisted fibres give an opaque appearance. This is especially noticeable under the low power of the microscope. (Fig. 8; and also 6 and 7.)

This test gains by contrast, when combined with the following methylen-blue test, recommended by Behrens; or with the copper-sulphate-potassium-ferrocyanide method proposed by the author.

The above mentioned oil test, and also the following tests, are carried out with small square fringed pieces of goods. With all methods a good microscope should be constanfly used.

Fig. 6. Half-linen subjected to oil test. Appearance with light falling upon it. In the illustration the cotton threads are vertical, the linen horizontal. Mag. 8x.

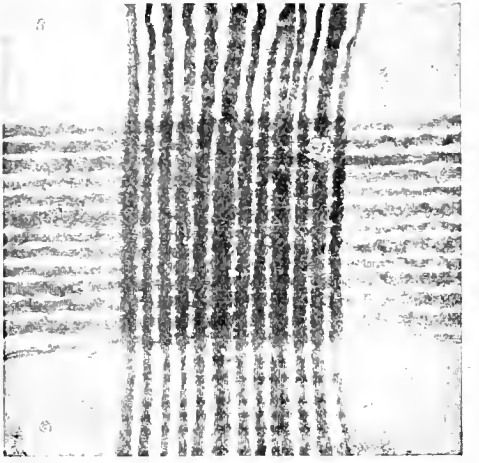


Fig. 7. Half-linen subjected to oil test. Appearance against the light. Cotton threads vertical, linen horizontal. Mag. 8x.

B. Chemical Tests

6. Sulphuric Acid Test. (Kindt and Lehnert).

The dressing-free, air-dry material is immersed from one to two minutes in concentrated sulphuric acid; next, well washed in water, and then dried between filter paper. Cotton under this treatment will dissolve almost completely; linen remains nearly unaffected. (Fig. 9.) This method of identification, available also for colored goods, is often employed to get an approximate quantitative estimate of half-linen goods. (Method of differentiation).

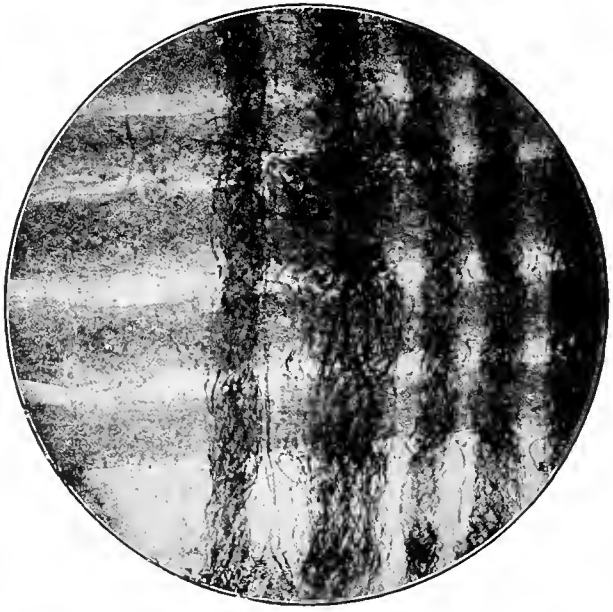


Fig. 8. Illustration of half-linen union goods oiled. Fibres run as in preceding illustration. Mag. 25x.

C. Dyeing Methods

The useful color tests for distinguishing cotton and linen fall into three groups. The first has for its basis the different *absorptive power* of both fibres for metallic salts; the second has reference to the slight *chemical difference* between the cell walls of cotton and flax fibres; and the third limits itself almost exclusively to

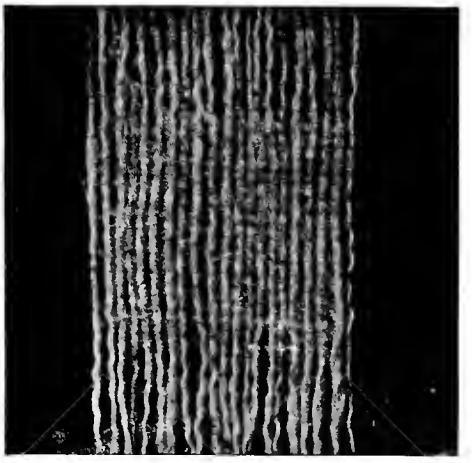


Fig. 9. Half-linen goods subjected to sulphuric acid test. Linen remains; cotton is almost entirely dissolved. Mag. 4x.

this fact—that the accompanying constituents of the flax fibre, namely epidermis and bark cells, which are rarely absent, are made especially prominent by appropriate dyes.

Group 1: Absorption Differences.

7. The author's copper sulphate and potassium ferrocyanide method is best adapted to this purpose. Although cotton dipped in a weak copper sulphate solution may retain appreciable quantities of copper salts, one can not succeed in proving these clearly in the fibre by means of potassium ferrocyanide. It is otherwise with the flax fibre, which absorbs approximately twice as much copper salts. The practical application of the test is as follows: A small piece of fringed material, free from dressing, is laid for ten minutes in a copper sulphate solution of a suitable strength, 10 per cent, and then washed under the faucet, to remove the adhering surplus of copper salt. Thus washed, the material is then placed in a 10 per cent solution of potassium ferrocyanide. If the material is half linen there appears in the part which consists of flax fibre (warp or woof) a striking copper-red color, due to the separation of ferrocyanide of copper; while the cotton fibres remain uncolored. Watch glasses may be employed for the experi-

ment. Beautiful results can be secured, if the above-treated piece of material is washed in water, and after thorough drying is enclosed in Canada balsam, in the same manner in which a slide is prepared for the microscope. In place of the Canada balsam a fatty oil may be used. As may be seen conclusively with the microscope, the coloring shown by the flax fibres is to be attributed not merely to the accompanying constituents, but is peculiar to the fibres. This detail is of especial analytical value in the examination of the finest linen batiste, which in certain circumstances is without the accompanying constituents. As microscopic examination shows, the difference in the coloring of the fibres and their accompaniments is to be noticed only to the extent that the former seems colored more of a copper-red, the latter more of a brick-red. The difference in the colors, especially after lying in Canada balsam, is more marked than in any of the other microscopic color tests known at present. Therefore the method just described may be especially recommended. The tests in which balsam is used are especially adapted to demonstration purposes.

Group II: Chemical Differences.

8. As a representative of this group, Behrens's methylen-blue test is here introduced. A small piece of woven material is colored in a warm solution of methylen-blue, and then washed thoroughly. On repeated washing it will be found that the coloring matter will almost entirely come out of the cotton, while in the same time the flax fibre appears colored a clear blue. In an earlier stage the cotton fibre appears a green-blue, different from the color of the flax. The distinction is especially noticeable by yellow lamplight. This test, like the one before mentioned, may be combined with the oil test. (See Fig. 10.)

At this point one detail should be noted. Although this method yields favorable results with correctly bleached flax and cotton fibres, it is uncertain as soon as fibres are used, which in the bleaching have undergone undesirable chemical changes (a change of cellulose into oxycellulose). According to investigations by Witz and others, the fibre substance, changed in part or wholly to oxycellulose, shows an especial affinity for methylen-blue. Therefore, in a half-linen weave containing improperly

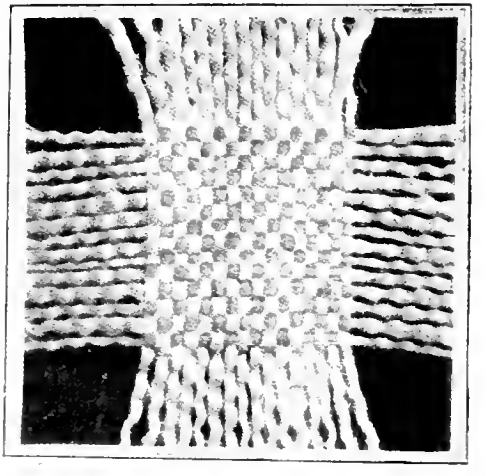
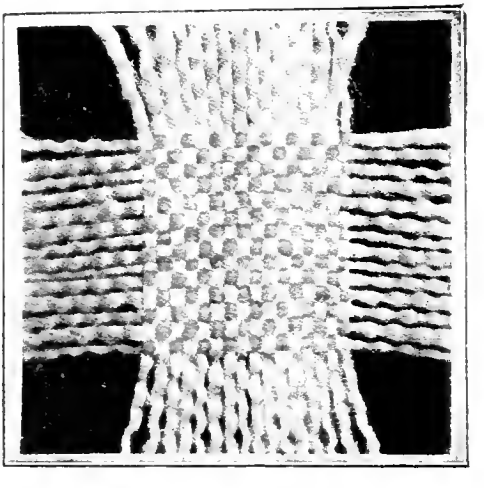


Fig. 10. Half-linen. Mag. 4x. Color test with methylen-blue. Linen fibre, *dark-blue;* cotton, *light-blue.*



Same as Fig. 10

Fig. 11. Half-linen. 4x mag. Color test with fuchsine and ammonia. Linen fibre *red;* cotton, *white.*

bleached cotton, the latter will hold the methylen-blue color even more firmly than the flax fibres. As it is not possible for the layman, without further instruction, to decide whether or not the undesirable change in the fibre substance has taken place, only a limited value attaches to the above method of examination.

9. Behrens has proposed other similar dyeing tests, e. g., with safranine, Bismarck brown, etc. Since with their help no better results are reached than with the methylen-blue dye, a special description of them is omitted.

Group III: Constituent Parts.

According to the older methods of this group alcoholic solutions (tinctures) of different natural dyestuffs were allowed to act upon the weave under examination. After about fifteen minutes the material is taken out of the dye, dried superficially between filter paper, and observed in moist condition. The result with madder and cochineal tinctures is as follows:

		Linen.	Cotton.
10.	Madder tincture:	*orange*	*pale yellow*
11.	Cochineal tincture:	*violet*	*pink*

Much better contrasts are obtained with Böttger's fuchsine or Herzog's cyanin test.

12. In Böttger's fuchsine test the weave is laid in a neutral alcoholic fuchsine solution for some minutes; then washed in water and laid in concentrated ammonia. The fuchsine dye will almost entirely leave the cotton, while in the impure flax fibre it remains a long time, though quite faded (rose colored). (See Fig. 11.)

13. The cyanin test given by the author is made as follows: A small square piece is cut from the weave to be examined, and fringed out. It is then laid for some minutes in a lukewarm alcoholic solution of cyanin (obtainable from Grübler & Co., Leipzig). After the resulting absorption of the dye, it is washed in water and then treated with diluted sulphuric acid. This effects a complete removal of color from cotton goods, while flax fibres in the same time show a clear blue color. This color is prominent in the

epidermis cells (especially the cuticle part), found in the flax fibre, since these seize upon the cyanin dye with avidity. To intensify the blue coloring it is recommended that the fibre, so treated with sulphuric acid, be thoroughly washed and placed in ammonia. The dye then appears to be substantially fixed in the flax.

Supplementary Tests

14. In conclusion, attention may be called to the fact that equally thick linen and cotton goods exhibit considerable difference in weight. According to K. B. Lehmann, linen goods of equal volume are about 17 per cent heavier. This fact, based upon the structural characteristics of both fibres, and their way of lying in the weave, should however be used only after much practice, and then with prudence, as a means of differentiation.

15. Cotton materials feel warmer than linen. The investigations by Rubner allow the conclusion that cotton by its peculiar structure makes the circulation of air difficult, and holds the heat more than linen goods of the same thickness. (From 15 to 30 per cent more.)

Mercerized Cotton

16. Mercerized cotton, so much used at present, is of recent discovery. It is obtained by treating ordinary cotton with strong sodium hydroxide solution with a simultaneous stretching of the fibres. It is characterized by a high lustre, almost like silk, and may be easily recognized by Lange's method. That is, if the cotton material is immersed in an iodine-saturated, concentrated solution of zinc chloride iodide, it is colored an intense blue. This color is easily removed from ordinary cotton by washing in water, while it remains fixed in the mercerized fibre. In the practical application of this test, also in the case of colored goods, any possible starch present in the dressing must be removed by long boiling in water.

17. Another method for the recognition of mercerized cotton has been suggested by Mr. David. It rests upon the fact that a *fibre mercerized for the second time shows after this treatment no further affinity for dye stuffs*. The thread or weave to be tested, if it is colored, is faded out as much as possible (e. g. with hydrochloric acid) and stretched on a frame. Then three solutions of sodium hydroxide are prepared: 1, a solution of 40° Bé; 2, one of

40° Bé diluted with an equal volume of water; 3, one diluted with three parts of water. The material stretched in the frame is now touched in different places along the stretched edge with these solutions. After a time the frame is dipped in water in order to wash out the sodium hydroxide, then acidified and again washed. Then follows coloring with a dye stuff, for instance, Congo red. If the weave so treated has not previously been mercerized, the touched places will take a considerably more intense color than the untouched part of the fabric. But mercerized fabrics show no difference in coloring.

18. For other means of distinguishing ordinary and mercerized cotton, we turn to the microscope. This is also effectual in recognizing silk finish and crepe finish.

II. Microscopic Tests

It should be pointed out concerning the foregoing, that many of the tests described may fail under special circumstances. This is readily understood, when it is remembered that in both raw products there is the same chemical substance, namely cellulose. With the lack of essential chemical differences, attention must be given to the foreign ingredients of the fibres, attendant on their production (the epidermis of the flax stalk, woody parts, etc.,) or to the morphological differences. The latter find their visible expression in the form of the fibres. Considering the extraordinary fineness of the cells composing the fibres it is apparent that a compound microscope is necessary for their examination.

The differences in structure, as shown by the microscope, are so constant and characteristic that they entirely exclude the possibility of an error in the diagnosis. *Therefore the greatest importance should be ascribed to the tests with the microscope, and its use is recommended in all cases where an absolutely certain determination must be reached.* With the present low price of microscopes the necessary expense to anyone buying textiles in quantity would soon pay for itself. The optical firm of E. Leitz in Wetzlar, Germany, has a small microscope on the market, which considering its low price and superior optical qualities, seems to me especially adapted to the foregoing purpose. Before buying instruments of lesser worth, cried up by various firms, one cannot be too strongly warned that they are useless for our pur-

pose. But on the other hand expensive and complicated instruments are not to be recommended since they are often constructed too delicately, and moreover lack the handy quality one needs for technical purposes. I have satisfied myself that the above mentioned instrument by Leitz meets all reasonable demands in a satisfactory manner. Moreover it is solidly built and enclosed in a small case, so that it is portable. It is, in short, most suitable for fibre identification tests.

When one considers that only a brief time is required both for the preparation and actual microscopic examination, and that a minimum of material is requisite, which is of great importance in testing patterns or samples which cannot be cut or otherwise

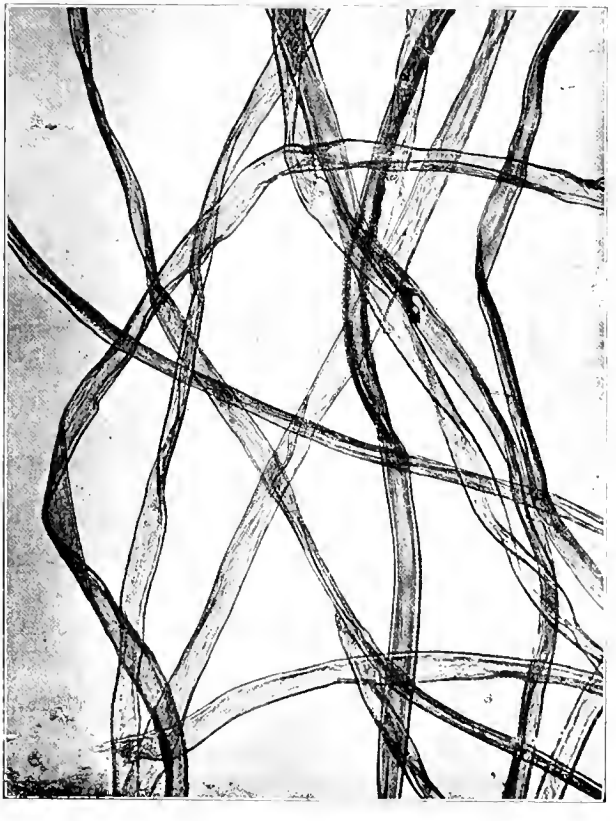


Fig. 12. Egyptian raw cotton shown under the microscope. Typical.

damaged, one can only express surprise that so little use is made of the microscopic method, so absolutely exact and so free from objections.

Cotton

Technically, cotton—unicellular and wooly-seeded—belongs to the Gossypium division (mallow family). The hairs are narrower at the base than in the middle, and measure 12-42 μ (1 μ = 0.001 mm.) in breadth, and 10-50 mm. in length (Wiesner). The cell wall is strongly developed and enfolded in an extraordinarily thin, granular or striped skin—the cuticle. It is twisted occasionally, more seldom in its whole length, like a corkscrew, and the stronger and more uniform the twisting, the better the quality (Hanausek and Herbig). On account of the peculiar shape of the cross section (reniform) the hollow fibre in the longitudinal view seems defined by calling it roll-shaped. The hair is closed at only one end. (See Fig. 12.)

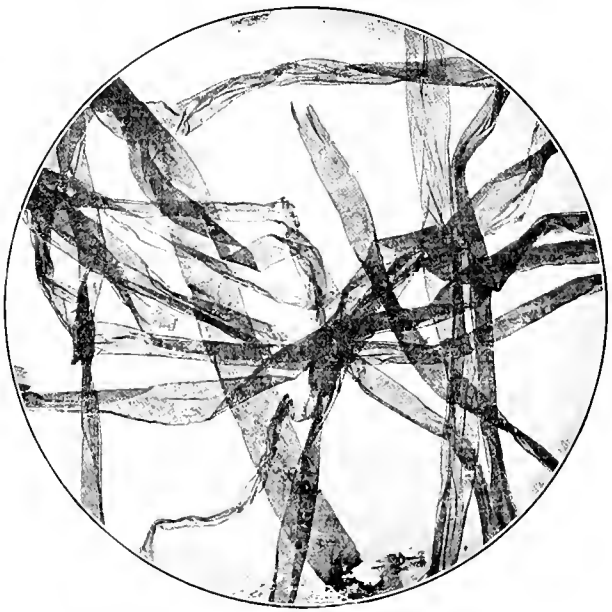


Fig. 13. Microscopic appearance of dead cotton.

The fibre is entirely free from wood, and therefore shows after treatment with zinc chloride iodide a clear cellulose reaction (red violet). The cross sections are elliptical to kidney-shaped, less frequently almost circular in the best kinds, with short columnar lumen. *Cotton shows characteristic modification after treatment with ammoniacal copper oxide.* However, it should be said that not all kinds of cotton give this appearance, just as that also many bast fibres yield an analogous swelled appearance.

With this treatment the cotton fibre swells up in blistered or barrel-shaped manner, until finally almost the last fragments of the cuticle and the inner skin with its traces of protoplasm, fully dissolve. The cuticle, which is not capable of swelling, is found on the outside of the fibre, in the form of shreds or a ring-like lacing. (See Fig. 23, page 30). A similar if somewhat less pronounced appearance results after treatment with iodine and diluted sulphuric acid.

With certain varieties will be found very weak-walled, slightly twisted fibres of dead and unripe cotton, with frequent double striping. It follows that their tendency to take dyestuffs to only a limited extent should be taken into account in the examination of colored goods of inferior quality. (See Fig. 13.)

Accurate identification of particular sorts of cotton is accomplished only with much difficulty; it is based on the measurement of the maximum breadth of hair most often appearing.

Cotton shows strong double refraction. Between crossed Nicols the fibres appear in polarization colors, first order (mostly yellowish), only in those places where they turn their narrower side (turning places) up. Colors of the second and higher order also appear. With parallel Nicols the corresponding complementary colors of the crossed position appear.

By such a method of examination, which naturally is possible only with a polarization apparatus, all inequalities and roughnesses of the fibre are apparent.

Cotton fibres colored with Congo-red in contradistinction to flax, appear only faintly dichroic. (Behrens.)

For distinguishing the hues of flax and cotton, the double coloring with safranine and chrysophen was proposed by Behrens. On account of the minor importance of these methods they will not be discussed here.

Mercerized Cotton

Under the microscope, the mercerized cotton of Mercer, also that of Thomas and Prévost (under tension), can easily be distinguished from the unmercerized. The former appears more or less stretched and smooth on the surface. The lumen of these cylindrically-shaped fibres shows, in different places, astonishing shrinkage and enlargements—many times it is scarcely visible. Internal granular fragments are often found. Steeped in ammoniacal copper oxide, the mercerized fibre swells quickly, so that almost the last trace of the inner skin dissolves. Peculiar forms of swelling are, however, not observed. After application of zinc chloride iodide, the fibre is colored more intensely than ordinary cotton. The transverse section shows a nearly circular form. As has already been suggested above, the directions given by Lange can be applied well to the microscopic investigation.

Silk Finish

In this place the tests of so-called silk—or ripple—calendered finish should be briefly considered. The beautiful and silk-like lustre which is lent to cotton goods (for the most part mercerized) by the silk finish, is produced by numerous very fine parallel press lines or ribs. These ribs are easily detected by placing a piece of

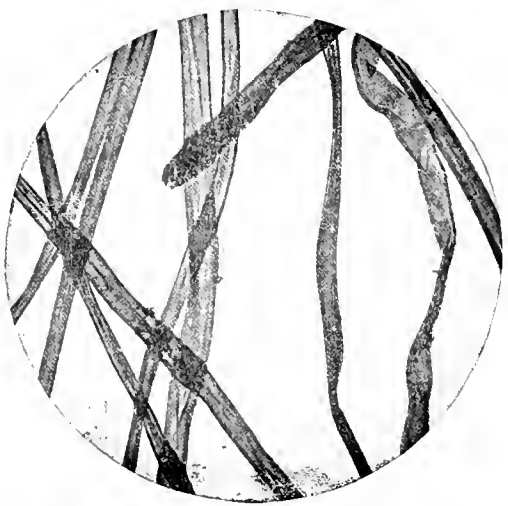


Fig. 14. Microscopic appearance of mercerized cotton. Mag. 150x.

the material under the lowest power of the microscope, and turning it backward and forward. It is better in this case to remove the selvage of the weave and look for press lines on the remaining prominent fibres. (See Fig. 15.) Similar effects are produced nowadays in the popular crepe material, although with the difference that the press lines follow a definite pattern.

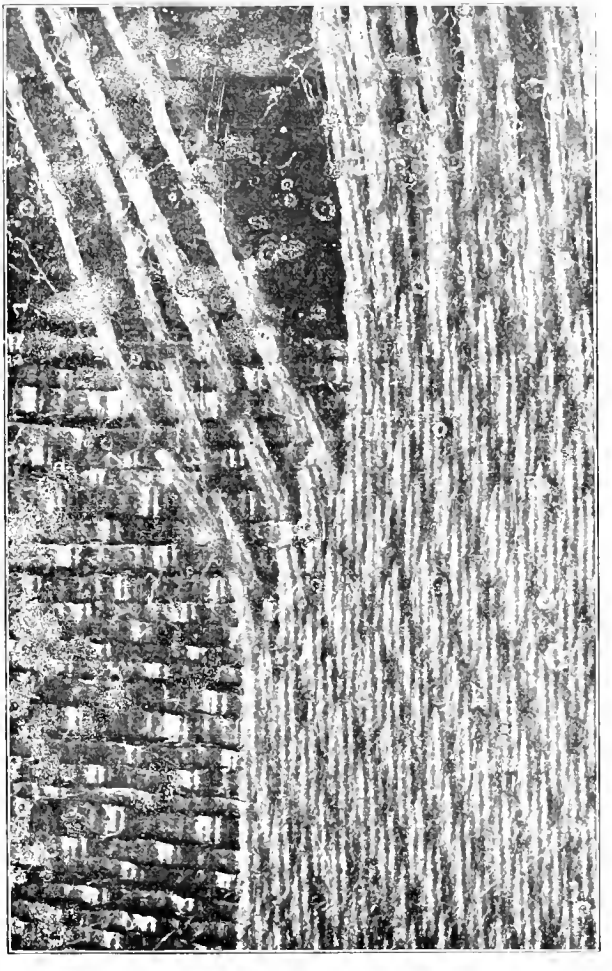


Fig. 15. Silk-finished calendered mercerized cotton. As shown in a magnifying glass.

Flax Fibre

The raw or unspun, unbleached flax fibre consists of numerous, united, bundle-forming primary bast fibres. The breaking down of a fibre bundle into its constituent parts begins under the chemical influence of bleaching. For this reason if we are proceeding to study raw fibre, we must first open up the bundle by boiling the flax with a caustic soda solution (about 10 per cent). With bleached fibres this preliminary treatment is not necessary.

The elementary bast fibres, according to the part of the stalk from which they are taken, show important differences in their

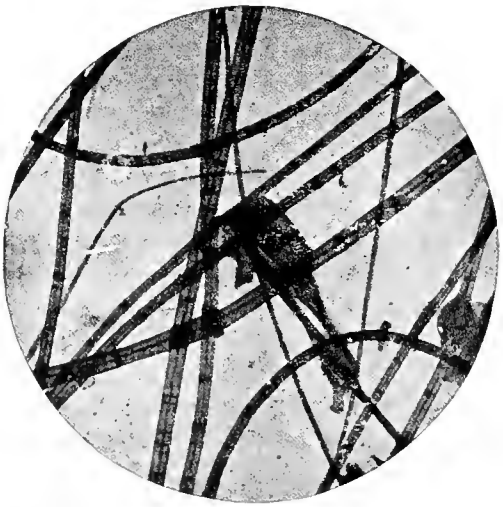


Fig. 16. Microscopic appearance of flax fibre in zinc chloride iodide. Mag. 100x.

microscopic structure. Then, too, characteristics of species and practices of culture (in particular the time of harvesting the flax), and other circumstances, bring about differences in the fibres which cannot be overlooked. The vast majority of fibres exhibit the following structure:—The primary fibers are arranged in groups and show sharply polygonal cross-sections. The cell wall is so strongly thickened that the enclosed lumen appears thread-like in the longitudinal view. The lumen is almost filled with dried particles of albumen. (See Fig. 16). In bleached

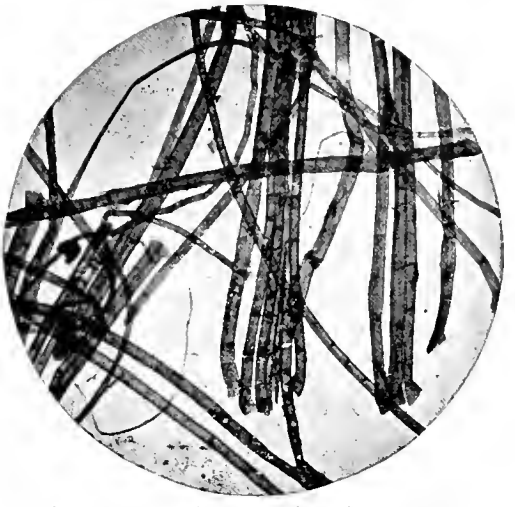


Fig. 17. Flax fibre in olive oil. Mag. 100x.

fibres the albumen ingredient may be lacking to a great extent. With zinc chloride iodide the cell walls are colored red violet, while the traces of albumen in the lumen take a yellow brown color.

In general the fibres are very uniform; they measure 21 *u* transversely. Both fibre ends run to a sharp point. The cell wall always shows a mechanical deformation of transverse knotty swellings, so-called displacements. These are especially prominent after treatment with zinc chloride iodide or fatty oil. (See Figs. 17, 18, and 19). The polariscope also gives excellent service in making them visible.

For manufacture of permanent specimens a coloring with safranine, according to my experience, answers very well. After fibres which have been well washed and thoroughly dried are enclosed in Canada balsam, the albumen-filled canal differentiates itself from the light red cell wall by its dark red color. The same methods may be employed for the observation of dichroism.

Another important microscopic test shows the fibres of the so-called root end of the flax stalk (the lower part of the flax stalk).

On account of the weakness of these fibres they offer little resistance to the vigorous mechanical preparation that they undergo, and in this way cause for the most part the fibre waste (tow).

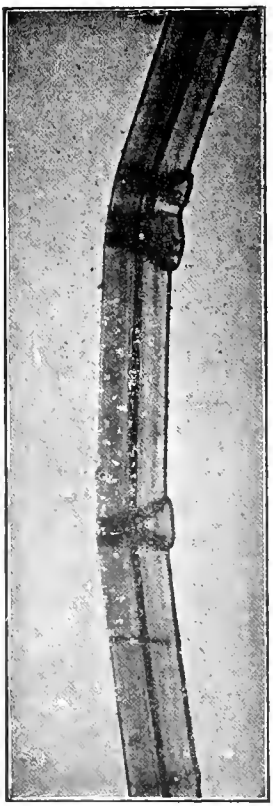


Fig. 18. Typical appearance of flax fibre from the middle of the stalk, in zinc chloride iodide. Fine fiber with clearly defined cell canal (filled with remains of albumen) and characteristic displacements. Mag. 400x.

They are therefore very frequently met with in tow-spun material. In longitudinal view, fibres from this part of the stalk appear very flattened, broad, and clearly stratified. (See Figs. 19, 20). The stripings are always observable. The cell ends are mostly rounded off. Zinc chloride iodide gives a red-violet color, occasionally muddy-greenish. The sound, intact fibre measures 52μ transversely. An exhaustive description of the morphological characteristics of the different parts of the stalk does not come within the scope of this pamphlet.

The flax fibre always shows a very strong specific double refraction. Observed between crossed Nicols, it appears uni-

Fig. 19. Typical appearance of flax root in zinc chloride iodide. Coarse fibre with wide lumen and small granular fragments of protoplasm. Cross markings—displacements—noticeably large. Mag. 400x.

formly colored in its greater extent. The predominant color is violet. The vivid polarization colors pass to the yellow, second order. The clearest results are obtained when the fibres are enclosed in a medium, the refractive index of which is very nearly identical with that of cellulose (Canada balsam or sodium salicylate). Flax fibres colored with Congo-red are strongly dichroic

(Behrens). By the backward and forward turning of the colored specimen on the object-stand, under which a Nicol has been inserted, the primary fibres are alternately intensely red and nearly colorless. Dichroism may also be observed after treating with zinc chloride iodide. With the exception of the macerated fibres from the root ends, which show deviations, the *following phenomena may be observed after putting flax fibres in freshly prepared ammoniacal copper oxide:* the cell wall shrinks, as Wiesner has pointed out, and dissolves under the appearance of a longitudi-

Fig. 20. Typical bast fibers from the lower part of the flax stalk. in chloride zinc iodide. Rather coarse fibre with clearly visible canal filled with traces of albumen. Longitudinal stripes apparent. Mag. 400x.

nal striping corresponding to the secondary thickened layers. At the same time the protoplasmic fragments of the lumen, circumscribed by the inner skin, shrink to a curved, wavy, faintly yellow tube. This soon breaks up and disintegrates by degrees into a granular mass. Similar phenomena are also observed after placing in iodine and diluted sulphuric acid. With the bast fibres of the lower part of the stalk, which are poor in albumen, there remains after steeping, a thin, sac-like skin, which faintly reminds one of the appearance that hemp shows. However, the foldings are not so pronounced by far, and a confusion of the fibres, with anything like accurate observation, may be put aside as impossible.

As has been before mentioned, the flax fibre has always certain accompanying constituent parts, which are of greatest importance for accurate identification. Valuable guiding elements are found in the form of epidermis fragments, with numerous slit-like openings, free from hair; and with coarser fibres in the form of

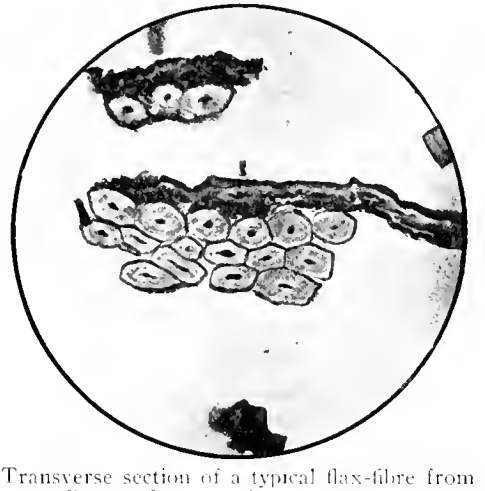


Fig. 21. Transverse section of a typical flax-fibre from middle of stem (Pernau-flax) in zinc chloride iodide. Mag. 300x.

chaff (the woody part, which by the technical method of treating the fibre cannot be entirely removed). Detailed information is found in the author's atlas—*Mikrophotographischer Atlas der technisch wichtigen Faserstoffe.* (J. B. Obernetter, Munich, Schillerstrasse 20.)

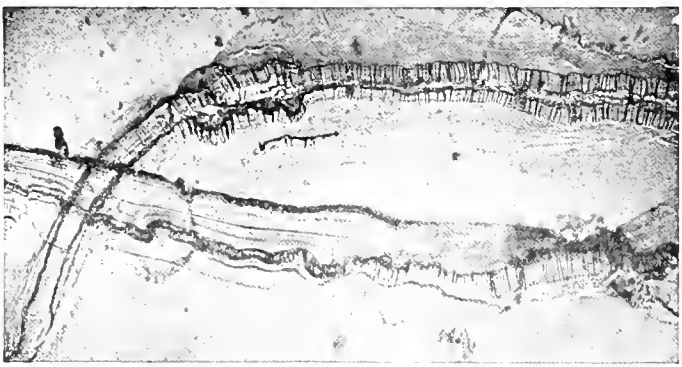


Fig. 22. Two hemp fibres, after treatment with ammoniacal copper oxide. Both fibers show a sac-like, much folded, inner skin. Mag. 100x.

Often with bleached fibres, only traces of the cuticle from the epidermis are found, which cover it in the form of a thin skin (perhaps 1-1.5). Along with this, moreover, the primary arrangement of epidermis cells may be clearly recognized. With zinc chloride iodide the epidermis part is colored yellow to yellow brown. With dew-retted flax fibres, numerous fungus-threads are also found which may be readily observed after the application of caustic potash or chloral hydrate. Most common are the fungus threads of one of the most common fungi: *Cladosporium herbarum Lk.* Water-retted flax shows this appearance only if

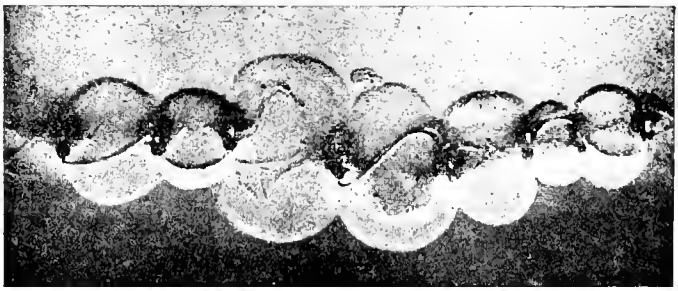


Fig. 23. Cotton fibres while being steeped in ammoniacal copper oxide. Mag. 100x.

the stalk, after harvesting, has undergone retting under bad atmospheric conditions. The above-mentioned woody parts are so easily recognizable that their characteristics under the microscope are omitted here. As already said, they appear only in coarse and badly cleaned material (tow).

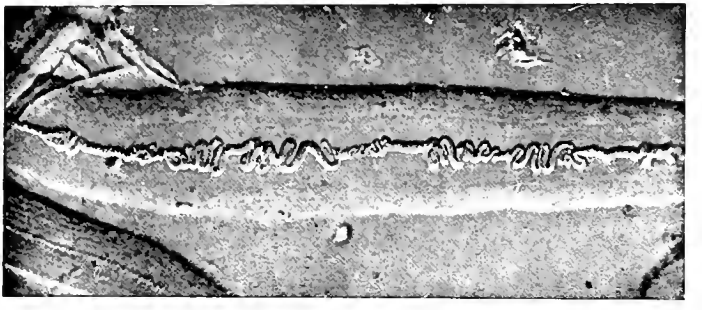


Fig. 24. Flax fibre while being steeped in ammoniacal copper oxide. Mag. 100x.

Appendix

In closing, I give the following summary of the reagents necessary for the execution of the described tests. Those marked * can best be obtained from a dealer in chemicals; the remaining substances are always kept by a druggist.

1. Olive oil.

2. Madder tincture, procured by extracting madder roots with alcohol.

*3. Cochineal tincture.

*4. Fuchsin.

*5. Methylen-blue.

*6. Cyanin.

7. 10 per cent copper sulphate solution.

8. 10 per cent solution of potassium ferrocyanide.

9. Concentrated sulphuric acid.

10. Diluted sulphuric acid. Concentrated sulphuric acid is carefully mixed with a little water, until cotton which has been treated with iodine potassium iodide dissolves with intense blue color under microscopic observation.

11. Ammonia.

12. Iodine in potassium iodide. In a strongly concentrated potassium iodide solution, the iodine is dissolved with a ruby red color.

*13. Zinc chloride iodide.

14. Ammoniacal copper oxide. Copper shavings are covered with concentrated ammonia and allowed to remain a half hour, with frequent shaking. On account of the ready decomposition of the liquid, it is best freshly prepared.

*15. 40° Bé sodium hydroxide solution.